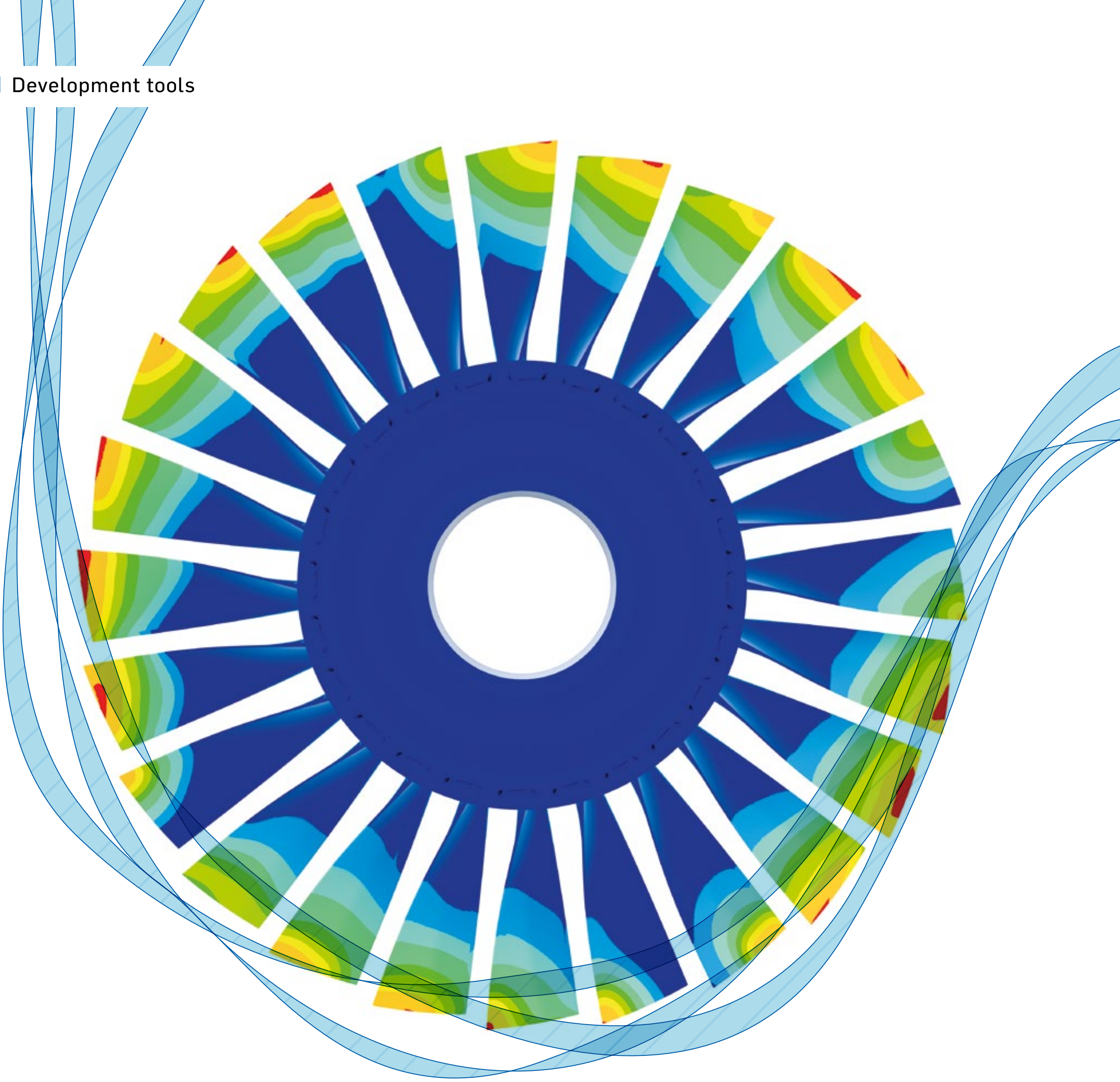


# Preventing mistuning with **ROMI**

Minuscule manufacturing tolerances can cause blades in turbomachinery to vibrate increasingly during operation. Researchers in Hanover have investigated the phenomenon, and have thus paved the way for even more efficient turbines.

## »It was important to predict an **increase in vibrational amplitudes –** and we succeeded in doing that.«

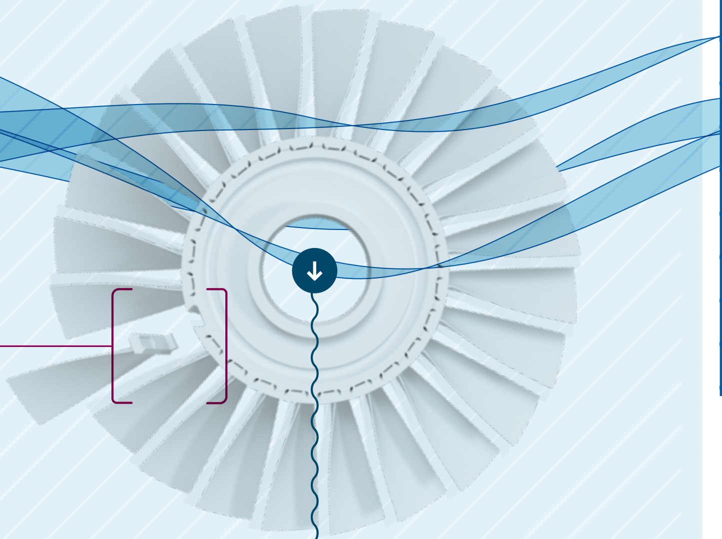
**Simulation of mistuning with aerodynamic coupling //** Turbomachines are precision machines; nevertheless, the geometry or material properties of the individual blades can vary minimally due to manufacturing tolerances. These deviations from the ideal geometry result in unwanted high vibrational amplitudes during operation – the system is ›mistuned‹. The mistuning effect occurs in all turbomachines, from small turbochargers to large steam turbines or aircraft engines. In an FVV project, researchers from Leibniz University in Hanover (LUH) examined how interactions with the fluid, such as steam or gas, affect mistuning. A simulation program was also developed in order to predict vibrational amplitude better in the future.

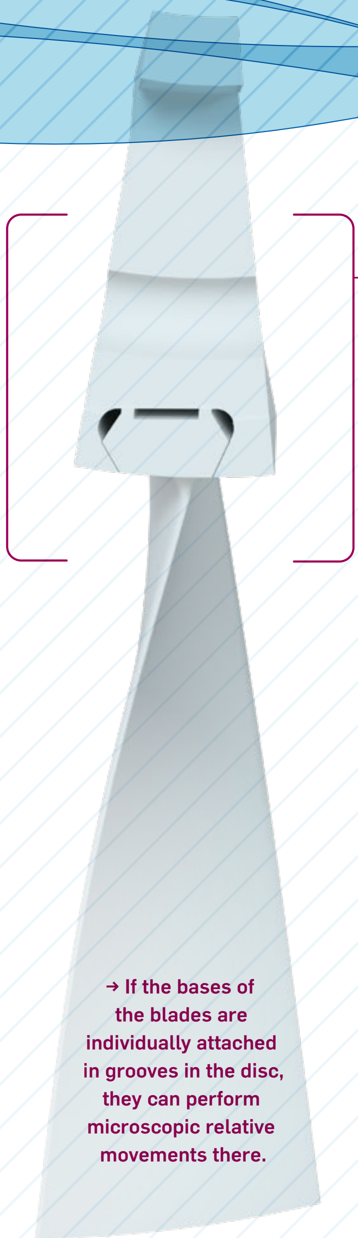
Until now, components have been designed to be stronger than necessary due to fear of these amplitudes, which can arise during operation as a result of mistuned blades. »The weight resulting from this cancels out the efforts to make turbomachines as efficient as possible,« explains Prof. Dr. Jörg Seume, Head and board member of the Institute of Turbomachinery and Fluid Dynamics at LUH. Seume reports that efficiency of highly effective gas power plants is increased by 0.3 percentage points every year, but only if the mistuning phenomena are conquered. Although this sounds like very little, over many years of operation it means that large amounts of fuel are saved – which would otherwise have caused $CO_2$ emissions. »The objective of the research and development work is to retain mechanical reliability while simultaneously increasing efficiency,« summarises Seume.

Misuning not only occurs as a result of manufacturing tolerances, but also due to coupling effects of the blades. »In a blisk (blade-integrated disk), the blades and rotor disc ultimately consist of a single component and are coupled solely through this. The fluid that flows through also couples the blades, which stimulates vibration,« reports Dr. Lars Panning-von Scheidt, Head of the Dynamics of Rotating Machinery research group at the Institute of Dynamics and Vibration Research at the LUH.

## Vibration calculation with ROMI

Mistuning of the blade properties leads to increased vibrational stress.






**Non-linear, structural-mechanical couplings** between blades and disc produce friction and lower the vibration amplitudes, which are determined by conducting experiments in a vacuum with vibration excitation using magnets.

The **aerodynamic coupling** of the blades influences damping in particular, which is determined by experiments on multi-stage turbo-machines under real flow conditions.

ROMI allows various effects to be observed both separately and simultaneously, with the aim of predicting vibrations of mistuned blades more accurately in the future.

## Project data

→ » Mistuning with Aerodynamic Coupling II [1269]: Mistuning of bladed discs with aerodynamic and structural coupling «

→ **PROJECT FUNDING**
€ 315,750 million // DFG, FVV

→ **PLANNING GROUP**
PG T ›Turbomachinery‹

→ **PROJECT COORDINATOR**
Dr. Harald Schönenborn, MTU Aero Engines

→ **RTD PERFORMERS**
Institute of Dynamics and Vibration Research (IDS) // Institute of Turbomachinery and Fluid Dynamics (TFD), both at Leibniz University in Hanover

If the bases of the blades are individually attached in grooves in the disc, they can perform microscopic relative movements there – further complicating the task of calculating vibrations.

In order to investigate the various possible influences, the researchers worked on two test benches with different configurations. The one at the Institute of Dynamics and Vibration Research was an idealised turbine stage in a chamber in which the effects could be reproduced without any disturbing influences. »Because the blades driven by an electric motor rotate in a vacuum here, we remove any interactions with the fluid,« comments Panning-von Scheidt. Structural-mechanical vibrations are created artificially: firstly with permanent magnets distributed throughout the chamber, and secondly in the static test with loudspeakers, which provide acoustic excitation. The test bench at the Institute of Turbomachinery and Fluid Dynamics, on the other hand, enabled real excitation through the flowing fluid and thus also allowed an investigation of damping. In modern gas or steam turbines, the mistuning in the last row of blades can be so great that the turbines cannot run in a stable manner without the additional damping effect of the flow.

The institutes used simulation software that was developed in a predecessor project and was now expanded. The ROMI (Reduced Order Model for Mistuned Turbine Blades) simulation program allows vibrations to be calculated while considering various coupling effects. Instead of external software developers, ROMI was written by a scientific staff member. And for a good reason: »We want to continue the project, so we always want to be able to adapt the code accordingly. That works better if we develop it ourselves,« explains Panning-von Scheidt.

During the course of elaborate test series spanning several months, the scientists examined how well the results of the simulation matched the real data. »There were small discrepancies due to the construction. With the current state-of-the-art in fluid dynamics, prediction errors are naturally somewhat greater,« says Seume, who is nonetheless satisfied: »It was important to predict an increase in vibrational amplitudes – and we succeeded in doing that.« //